L. The Integration of Punctiform Cold and Pressure

By S. Tung

The experiments described in this paper were undertaken to discover what psychologically results from the simultaneous stimulation of cold and pressure spots. So far as we are aware no previous attempt has been made to synthetize cold and pressure with punctiform stimulation. Some investigators, however, have said that the areal stimulation of the organs of these two qualities gives the experience of wetness. Helmholtz, for instance, remarks that "das scheinbar einfache Gefühl des Nassen, welches ein berührter Körper erzeugt, . . . aus dem des Glatten und des Kalten zusammengesetzt [ist]," [1] and Bentley has shown that under experimental conditions wetness may in fact result from stimulation with a dry smooth object (such as rubber sheeting) the temperature of which is either above or below that of the skin.[2] Thunberg, on the other hand, writes: "Eine Kälteempfindung, welche von einer Berührungsempfindung nicht begleitet ist, wird häufig als von einer Flüssigkeit verursacht aufgefasst, was daraus erklärt werden kann, dass beim Niedertauchen eines Körperteiles in eine Flüssigkeit der Drucksinn fast gar nicht erregt wird, dass also die entstehenden Temperaturempfindungen ungemischt sind. Im Zusammenhang damit steht eine eigentümliche Illusion von Nässe, welche entsteht wenn man die Stirn mit einem sehr kalten Gegenstande z. B. 20 Sek. berührt. Nach dessen Fortnahme dauert die Kälteempfindung noch einige Zeit fort und zugleich hat man den Eindruck, dass die Stirnhaut deutlich nass sei."[3] Fröbes says, even more emphatically: "Die Qualität 'nass' scheint nichts anders als einfache Kälteempfindung ohne gleichzeitige Berührungsempfindung."[4] The difference of opinion expressed by these authors can, of course, be settled only by experiment, and since we employed a punctiform and not an areal mode of stimulation, we are unable definitely to settle it. We may say, however, that under our conditions wetness (or, more accurately, a 'cold wetness') was found frequently to occur with simultaneous stimulation of pressure and cold spots, and that the experience was never observed when spots adequate only to their normal stimulus were excited singly. We now give a more detailed account of our methods and a more complete statement of our results.

Our first method was to stimulate with a cold-point spots on the surface of the fore-arm which responded both to pressure and to

[1] H. Helmholtz, *Physiologische Optik*, 1866, 698; 1896, 845.

[2] M. Bentley, The Synthetic Experiment, this Journal, xi, 1900, 414ff. See also E. B. Titchener, *Beginner's Psychology*, 1915, 47.

[3] T. Thunberg, in Nagel's *Handbuch der Physiologie des Menschen*, iii, 1905, 708.

[4] J. Fröbes, *Lehrbuch der experimentellen Psychologie*, i, 1917, 134. No authority is cited for this statement, but we suspect that it was taken from Thunberg's article. Thunberg does not mention Bentley's paper.

cold. We had planned to check the results thus obtained by stimulating in the same way cold spots that did not respond also to pressure, but we were unable to find spots of this kind because the intensity of pressure furnished by our apparatus was too great. As stimulus we employed a thermaesthesiometer with cold water running through the point. This was attached to a spring balance modeled after Thunberg's algesometer,[5] and the whole was mounted on a universal standard. The amount of pressure, as measured on a pressure balance, was 16 gr., with an mv. of 10% due to the difficulty of controlling adequately the weight of the water conduit. The temperature of the water varied between 18° and 21° C., and that of the room in which we worked between 21° and 26° C.[6] The point of the aesthesiometer was smoothly rounded and measured 1 mm. in diam. The fore-arm was placed in a warm plaster cast. The spots to be stimulated were permanently marked by tattooing. The observers were Professor Weld (W), Dr. L. B. Hoisington (H), Mr. S. Takaki (Ta), and the writer (Tu); Mr. Takaki served as *E* for the latter. The instruction given to the *O*'s was as follows: "I shall stimulate a spot on your arm, and you are asked to report the course, particularly with regard to quality and intensity, of the cutaneous experience."

Results obtained by the First Method. In early experiments the course of the experience was, in general, described by all *O*'s as, first, a pressure of low intensity which quickly passed into a cold; this, after an interval, changed into another cold which then, gradually and with fluctuations, faded out. Later the two qualities of cold were distinguished, the first as a superficial 'wet' cold, the second as 'just cold,' deep and penetrating. Typical characterizations of these colds are as follows:

W. "I felt chill, like a piece of ice touching the skin, which first penetrated deeply then quickly spread out." "Wet was felt but it disappeared rather quickly, then a deep cold that was not in the least wet." "I had first the impression of wetness like a drop of cold water."

H. "At intermediate intensity I felt something like a piece of ice with a strip of cloth surrounding it. Wetness was not sharply felt except at the edge of the spot; it did not last long. After wetness was gone, just cold was left behind." "The wetness was like water; as I felt it less as the cold became more intense." "The wetness was on the surface; the cold beneath the surface of the skin."

Ta. "I felt something smooth wet and cold at the spot like ice melting; . . . after wetness was gone I felt simply cold like the coldness of metal."

The wet cold was reported in about 80% of the trials; in some instances cold did not appear at all; in others it was long delayed, as a result, we suppose, of a relative displacement of the cold-organ and the tattooed spot. It was a logical inference that the change from the wet to the dry cold might be due to the earlier adaptation of the pressure, and we found by rough experiments that the average adaptation time of pressure was in fact only about ¼ that of cold. If the above inference is correct, we should be able to obtain a return of the wet cold by restimulation of the spot with a pressure-stimulus

[5] T. Thunberg, *Skand. Archiv.*, xii, 1902, 424.

[6] A lower temperature of the water was avoided because of the production of moisture by condensation on the metal point.

after the wet cold has gone but before the second cold has disappeared. We tried this experiment, and in some instances were successful. It was essential to success to employ a relatively weak stimulus (a hair), to apply it as close to the cold stimulus as possible, and to direct *O*'s attention to the cold; if the cold was not focal, a pressure was reported within an area of cold.

Our second method was that of simultaneous stimulation of discrete pressure and cold spots. For pressure we employed hairs of 3.0 and 4.2 gr/mm tension value; for cold it was essential to our method to excite the cold spot without touching the skin. In order to do this we found by trial that exceptionally low temperatures of stimulus were necessary; and the only one that proved adequate was obtained from a mixture of ether and carbon-dioxide snow.[7] This was managed in the following way: a Willyoung thermaesthesiometer, with thermometer removed, was clamped to a universal standard; it was first filled with the snow, and then the ether was added. When this was done the temperature of the mixture fell quickly to about —78° C., a heavy vapor streamed down perpendicularly from the instrument, and a thick frost accumulated on it. Since the vapor was felt as a 'damp cold,' and falling particles of frost as 'wet cold,' we were forced to wait until the violent stage of evaporation was over; thereupon the stimulus was ready for use. Our subsequent procedure was as follows: the cold stimulus was first lowered and adjusted in such fashion that the point of the instrument was directly over a cold spot. The distance above the surface of the skin varied from 2 mm. to 10 mm., depending upon the state of the mixture or upon the readiness of response of the cold spot. When *O* had reported a cold of good intensity, a signal was given, and a pressure spot in the immediate neighborhood of the cold spot was stimulated by the hair. *O* was instructed to describe the qualitative course of the cold after the signal.

Results obtained by the Second Method. We again frequently, although not invariably, obtained reports of 'wet cold.' At times, however, the pressure was not realised either as pressure or as anything else, and at others pressure was felt in an area of cold. These results seemed to be due either to a lapse of attention to the cold (a condition which our instruction was designed to meet), or else to the lack of a proper proportion of the intensities of cold and pressure; for example, we found that the pressure was most frequently not felt when the intensity of cold was strong, and that it generally appeared in a spatial pattern with cold when the cold was weak. We regret that we were unable, for want of time, to make a systematic study of this point. But it appears probable that the appearance of 'wet cold' is, aside from the mode of stimulation, conditioned both upon the greater clearness of cold and upon a certain relation between the intensities of cold and pressure. When the 'wet cold' occurred it came sud-

[7] We tried without success the apparatus of the first method with the point cooled by an ice-salt solution, a temperature cylinder also cooled by an ice-salt solution, a mica shield with small holes in it for receiving the pressure stimulus and for conducting cold from a block of ice, and an ice-ammonium chloride solution in the Willyoung apparatus. The department of physics in Cornell University kindly supplied the carbon-dioxide snow, and gave us the temperature of the mixture.

denly, with surprising distinctness, and lasted for a very brief interval. It was characterised as like a "melting flake of snow," "a drop of cold water," "a tiny particle of ice." The 'radiant cold' on the other hand was reported as "not punctiform but areal, less intense, and more penetrating than the 'wet cold;'" "it was like the 'dry cold' of the other experiment," "like the feel of a cool breeze without pressure, or the cold of evaporating ether."

The fact that 'wet cold' may derive from a simultaneous stimulation of cold and pressure spots is, of course, only a single result. The duration of the experience was, under our conditions, so brief that our *O*'s were baffled in their attempts to give a qualitative description of wetness. But an investigation of the synthesis of pressure and warmth with punctiform stimulation is now being made in the laboratory, and a systematic study of Thunberg's illusion is also under way. These two inquiries should throw further light upon that problem.